HHS Public Access

Author manuscript

*Weather Clim Soc*. Author manuscript; available in PMC 2016 May 26.

Published in final edited form as:

*Weather Clim Soc*. 2014 January ; 6: 22–31. doi:10.1175/WCAS-D-13-00023.1.

# Evaluation of the National Weather Service Extreme Cold Warning Experiment in North Dakota

**Cindy H. Chiu**,
National Center for Environmental Health, Centers for Disease Control and Prevention, Atlanta, Georgia

**Sara J. Vagi**,
National Center for Environmental Health, Centers for Disease Control and Prevention, Atlanta, Georgia

**Amy F. Wolkin**,
National Center for Environmental Health, Centers for Disease Control and Prevention, Atlanta, Georgia

**John Paul Martin**, and
NOAA/National Weather Service/Weather Forecast Office, Bismarck, North Dakota

**Rebecca S. Noe**
National Center for Environmental Health, Centers for Disease Control and Prevention, Atlanta, Georgia

## Abstract

Dangerously cold weather threatens life and property. During periods of extreme cold due to wind chill, the National Weather Service (NWS) issues wind chill warnings to prompt the public to take action to mitigate risks. Wind chill warnings are based on ambient temperatures and wind speeds. Since 2010, NWS has piloted a new extreme cold warning issued for cold temperatures in wind and nonwind conditions. The North Dakota Department of Health, NWS, and the Centers for Disease Control and Prevention collaborated in conducting household surveys in Burleigh County, North Dakota, to evaluate this new warning. The objectives of the evaluation were to assess whether residents heard the new warning and to determine if protective behaviors were prompted by the warning. This was a cross-sectional survey design using the Community Assessment for Public Health Emergency Response (CASPER) methodology to select a statistically representative sample of households from Burleigh County. From 10 to 11 April 2012, 188 door-to-door household interviews were completed. The CASPER methodology uses probability sampling with weighted analysis to estimate the number and percentage of households with a specific response within Burleigh County. The majority of households reported having heard both the extreme cold and wind chill warnings, and both warnings prompted protective behaviors. These results suggest this community heard the new warning and took protective actions after hearing the warning.

*Corresponding author address*: Rebecca S. Noe, National Center for Environmental Health, CDC, 4770 Buford Hwy., MS F-60, Atlanta, GA 30341. ; Email: rhn9@cdc.gov

## 1. Introduction

Exposure to extreme winter temperature can cause frost bite, hypothermia, and even death (Centers for Disease Control and Prevention 2005; National Weather Service 2008). Frostbite is injury to the body caused by freezing temperatures and in severe cases, frostbite can lead to permanent damage and amputation. Hypothermia, defined by a core body temperature of <95°F (<35°C), can lead to organ failure and death, or permanent organ damage in those who survive. The hypothermia-related mortality rate has been estimated to be 4 per 1 000 000 persons per year in the United States, resulting in 4607 deaths during the 1999–2002 period (Centers for Disease Control and Prevention 2005, 2006). The hypothermia and other cold-related morbidity rate had also been estimated using emergency department visits, with 15 574 emergency department visits during 1995–2004 and an annual incidence of 5.6 per 1 000 000 persons in the United States (Baumgartner et al. 2008). Although morbidity related to extreme cold weather has not been systematically assessed, apart from frostbite and hypothermia, extremely low temperatures can exacerbate preexisting chronic conditions such as asthma (Kaminsky et al. 2000) and cardiovascular disorder (Panagiotakos et al. 2004).

In addition to affecting life, extreme winter temperatures can also harm property, including livestock, pipes, and vehicles (Centers for Disease Control and Prevention 2012b; National Weather Service 2008). The Centers for Disease Control and Prevention (CDC) and the National Oceanic and Atmospheric Administration (NOAA) recommend individuals take protective action during extreme winter temperatures, including dressing warmly and staying dry, avoiding traveling, keeping pets indoors or ensuring outdoor pets have adequate shelter and access to unfrozen water, weatherproofing homes, insulating water pipes, and servicing vehicles annually before the winter season (Centers for Disease Control and Prevention 2012b; National Weather Service 2008).

The National Weather Service (NWS) is responsible for issuing weather forecasts and warnings for the protection of life and property. Since 1973, NWS has used wind chill warnings during periods of dangerously cold wind chills (National Oceanic and Atmospheric Administration 2003). The general criteria for issuing wind chill warnings are typically ambient temperatures ≤−40°F and wind speeds ≥3 mph; however, the triggering temperature is set locally and can vary from state to state (Fig. 1). Wind chill warnings are issued 12–48 h before the criteria are expected to be met to allow sufficient time for the public to take protective actions (National Weather Service 2009). Generally, wind chill warnings are not issued when the wind speed is <3 mph, despite dangerously cold weather. To fill this gap, several NWS Forecast Offices experimented with a new extreme cold warning (National Weather Service 2011). Extreme cold warnings were issued for both wind and nonwind conditions. The extreme cold warning, although not used for public warning in the past, has been effectively used in the NWS-Alaska region to warn the aviation industry against frozen fuels and hydraulic lines (National Weather Service 2012). The criteria for the extreme cold warning are also set locally, with the typical criteria defined as a temperature or wind chill ≤−30°F for an extended amount of time (≥3 h) over a large geographical area (≥3 counties) (Fig. 1).

In 2012, the extreme cold warnings were piloted at eight NWS forecast offices, including offices in North Dakota, South Dakota, Minnesota, and Arkansas (National Weather Service 2012). The NWS-Bismarck Weather Forecast Office and the North Dakota Department of Health (NDDoH) sought to understand whether local residents heard the new warning and were prompted to take protective action by the warning. This led to a population-based household survey in Burleigh County, North Dakota, to evaluate the extreme cold warning in this community, jointly conducted by the CDC, the NDDoH, and the NWS-Bismarck Weather Forecast Office. The objectives of this survey were to assess whether residents heard the new warning and were prompted to take protective action by the warning, to determine protective actions taken by residents during extreme cold events, and to identify preferred advance warning time among the residents of Burleigh County.

## 2. Methods

### a. Sampling methodology

We conducted a cross-sectional survey in Burleigh County (2011 population estimate = 85 774), which includes Bismarck (population = 64 751), the second largest city in the state of North Dakota. The majority of Burleigh County residents are white (93.2%). The median age in Burleigh County is 37.3 years old and the average annual household income is $56 231. Most residents (67%) work in services, manufacturing, and government industries, while 3% work in the agriculture sector (U.S. Census Bureau 2012). This region is the most populated of the NWS Bismarck office’s county warning area within the extreme cold warning pilot area.

We used the Community Assessment for Public Health Emergency Response (CASPER) methodology to select a representative sample of the targeted community (i.e., Burleigh County) (Centers for Disease Control and Prevention 2012a). CASPER is an epidemiologic method designed to provide household-based information, and uses a two-stage probability sampling technique to select 210 households to be interviewed. In the first stage, 30 clusters (usually census blocks) from the 2010 census were selected from the target area. In the second stage, interview teams systematically selected seven households from each of the 30 clusters, for a total of 210 interviews.

In Burleigh County, the rural and urban areas based on 2010 census data contained 1443 and 32 725 housing units, respectively. Clusters in the rural area were less likely to be selected using the probability-proportional-to-size sampling methodology, given the lower number and density of housing units in the rural area. To ensure representativeness of the rural population, we stratified Burleigh County into rural and urban areas based on the 2010 census data and local knowledge of the county, and then oversampled the rural households (urban area: 23 clusters; rural area: 7 clusters). The greater Bismarck area, including the city of Lincoln, was defined as urban; the rest of the sample area was defined as rural (Fig. 2).

### b. Design of the survey questionnaire

The CASPER questionnaire addressed the following topics: 1) public acceptability of NWS’s winter weather warnings, 2) concerns and actions during extreme cold weather

events, 3) main source of information for extreme weather, 4) preferred advance warning time, and 5) satisfaction with NWS winter warnings and forecasts. The survey questions used are reproduced in the appendix. To determine the acceptability of winter warnings, households were asked if they had heard the extreme cold and wind chill warnings issued and if they had prompted a protective action. To assess concerns and behavior during extreme cold weather events, interviewers asked participants what they would be concerned about after hearing the extreme cold warning, then listed six “typical” concerns one might have after hearing an extreme cold warning, and obtained yes/no answers. Behaviors were assessed by interviewers first defining an extreme cold event and then asking if seven expected protective actions were taken immediately before or during previous periods of extreme cold weather.

Participants reported their preferred advance warning time and chose their main source of severe weather information from a list of communication means. General satisfaction of NWS winter warnings and forecasts were assessed using a five-point Likert scale, which ranks satisfaction or dissatisfaction on four performance indicators (accuracy, timeliness, reliability, and language used).

### c. Field interviews

Twelve two-person interview teams conducted all interviews between 0700 and 2000 LT 10–11 April 2012. The interviewers were staff from the NDDoH and the CDC. NWS staff acted as observers with one of the teams. The teams were trained on the overall purpose of the survey, the questionnaire, interview techniques, and the household selection method. Eligible participants were household residents 18 years of age or older who responded to the questions on behalf of the entire household.

### d. Data analysis

We calculated the response rates and conducted weighted analysis for each response to account for the sampling probabilities of the households within each cluster and oversampling based on urban/rural strata. We provided projected estimates of the number and percent of households with a particular response within our target area (Burleigh County). Data analysis was conducted in SAS 9.3 to calculate weighted frequencies, percentages, 95% confidence intervals (CI), and $\chi^2$ statistics. We used the more conservative approach and compared weighted confidence intervals for urban and rural responses in Epi-Info 7 to identify statistically significant differences indicated by the lack of overlap between confidence intervals. Unless otherwise stated, percentages in the text represent the weighted percentages.

## 3. Results

### a. Response rates

We conducted 188 interviews of the target 210 interviews with a completion rate of 89.5% (Table 1). A total of 483 homes were approached, someone answered the door in 294 homes, and 188 homes had an eligible participant with whom the interview was conducted. The

most common reason for nonparticipation for those who answered the door was refusal. Forty-one interviews were conducted in the rural clusters and 147 in the urban clusters.

### b. Winter weather warnings and action taken

Of the households interviewed, 86.6% reported having heard the extreme cold warning previously, and of those who heard the warning, 78.9% reported taking protective action (Table 2). All of the households (100%) reported having heard the wind chill warning previously and of those who heard the warning, 84.7% reported taking protective action. The difference in proportion of households who heard the extreme cold warning compared to wind chill warning was statistically significant: $\chi^2(1, N = 374) = 24.77$, $p < 0.0001$. However, although the proportion of those who took action after hearing the wind chill warning was slightly higher than after hearing the extreme cold warning, the difference was not statistically significant: $\chi^2(1, N = 351) = 2.57$, $p = 0.109$.

### c. Concerns and behaviors after hearing extreme cold warning

The most common concerns after hearing the extreme cold warning were loss of power (71.0%), health issues such as frostbite and hypothermia (60.9%), and automobile not starting (60.8%; Table 3). The majority of households (44.3%) had 4–6 concerns, followed by 43.1% who had 1–3 concerns; 8.5% had no concerns. On average, households had three concerns after hearing the extreme cold warning [weighted mean = 3.4; standard error (SE) = 0.21]. Immediately before or during an extreme cold event, the most common protective actions were wearing extra clothing (91.6%), ensuring vehicles were in good working order for winter weather (87.6%), and staying indoors (77.5%; Table 3). Rural households (74.4%, 95% CI: 63.3–85.5) were more likely to ensure alternative forms of home heating were available compared to urban households (50.2%, 95% CI: 41.2–59.3). The majority of households (55.4%) took 4–6 protective actions, followed by 36.0% who took ≥7 actions; 0.8% took no actions. On average, households took six protective actions immediately before or during an extreme cold event (weighted mean = 5.6; SE = 0.12).

### d. Communication strategy and preferred warning time

The majority of households (81.0%) reported television as their main information source for severe winter weather (Table 4). Commercial radio was the next most common main information source (23.5%, 95% CI: 13.8–33.3) for rural households, while the Internet was the second most common for urban households (6.0%, 95% CI: 1.7–10.3). The most common preferred extreme cold warning time prior to the event was 1–2 days (44.9%), followed by 6–24 hours (40.0%).

### e. Satisfaction with NWS warnings and forecasts

With regard to the NWS's winter warnings and forecasts, the vast majority of households reported being very satisfied or satisfied with the accuracy (85.0%), timeliness (93.3%), reliability (85.3%), and language used (95.1%) (Table 5).

## 4. Discussion

This study was conducted in Burleigh County to investigate the effectiveness of a new NWS winter warning and to identify the community's concerns and behaviors in extreme cold events. North Dakota has the second highest hypothermia-related mortality rate in the country, and was one of the locations where the extreme cold warning pilot experiment took place (Centers for Disease Control and Prevention 2005). Most previous evaluations of NWS messaging elucidated important information but relied on convenience sampling instead of probability-based sampling and therefore have limited generalizability to their target populations (Zhang et al. 2007; Joslyn et al. 2009; Hoekstra et al. 2011). We used an existing epidemiological tool to draw a representative sample from our sampling frame, Burleigh County, to conduct this survey.

Overall, the majority of households reported having heard an extreme cold warning at least once, with the majority taking action after hearing the warnings. Extreme cold warnings have been issued for four separate events by NWS-Bismarck during 2011–12. More households reported having heard a wind chill warning previously compared to an extreme cold warning, presumably because of the longer period of time the wind chill warning has been in use. However, there was no difference in the proportion of people taking protective action after hearing either warning, suggesting both warnings if heard were equally effective at prompting protective actions. We were able to identify cold weather concerns and actions households took during an extreme cold event. The majority of the Burleigh County households were knowledgeable about severe winter weather and took on average six protective actions recommended by the CDC and NOAA against extreme cold weather (Centers for Disease Control and Prevention 2012b; National Weather Service 2008). Although relatively few households reported having no concern or took no action, this still translates to a sizeable population estimate (no concern = 2913 households; no action = 285 households) that might be complacent. We conducted this survey in spring instead during winter, when participants would be more likely to remember what they did during extreme cold events; therefore, results are potentially affected by recall bias.

We assessed the main communication strategy to reach the community about severe winter weather. Television was the main severe winter weather information source and less than 6% of the households reported using the Internet as their main source of information despite the rapid expansion of social media and the high socioeconomic status of the Burleigh County residents. However, these results should be interpreted with caution, as households were limited to select their main source of information instead of reporting all information sources used to gather severe weather information. North Dakota should continue to emphasize television as a key medium to warn the community regarding severe weather events, supplemented by other media sources to reach all residents and in the event of power outages (U.S. Department of Homeland Security 2007). The public's most desirable warning times were 1–2 days followed by 6–24 hours, which was encouraging given its consistency with NWS's established goal to warn the public a day or so before extreme cold conditions (National Weather Service 2008).

Finally, our results showed that the vast majority of households were “very satisfied” or “satisfied” with NWS’s warnings and forecasts. However, the community may have misinterpreted “NWS” to mean the broadcast (television) or other media meteorologists, in which case the high satisfaction rate may represent satisfaction with commercial meteorologists. In addition, the responses could have been biased given the surveys were conducted by public health staff from the state and federal governments.

### Directions for future research

The purpose of this survey was to assess the knowledge, attitudes, and practices in the population of Burleigh County regarding a specific warning message distributed by the NWS. The goal was to obtain quick information that was generalizable to the target area, to be used for local public health planning but not necessarily generalizable to the population at large. The results, while accomplishing the intended purpose, also raise many questions about the distribution of answers in the population and factors affecting differences in responses. For example, previous research suggests small social, cultural, and demographic differences in behaviors elicited in response to warnings (Lindell and Perry 2004). This means that individual, household, and situational differences might influence differential responses. Similarly, the relationship between attitudes or concerns and propensity to take protective action, and the cognitive processes connecting the two, were not thoroughly investigated in this survey. These and other factors that may affect the relationship between hearing the warning and taking action are encouraged for future research but were beyond the scope of this practical assessment.

## 5. Conclusions

This survey was conducted to help the NDDoH and NWS-Bismarck determine whether the new “extreme cold warning” was effective among their service population in Burleigh County, North Dakota. This is one of the first times the NWS has partnered with public health practitioners to use a representative sampling methodology to assess whether weather warnings were heard by the local community and whether the community was prompted to take actions they perceived as protective. Collaborations for similar assessments in the future are encouraged to assess other existing or new warnings and in other areas, particularly with NWS’s growing interest to add public health messaging to their warnings. The NWS’s Weather-Ready Nation Initiative and the signing of the new CDC–NOAA Memorandum of Understanding in 2011 may facilitate future work between the agencies to improve weather warnings to the public to prevent weather-related morbidity and mortality (National Oceanic and Atmospheric Administration 2012).

## Acknowledgments

We thank Dr. Stephen Pickard and Ms. Tracy Millar from the North Dakota Department of Health for their assistance and support in making this project possible. Also, we thank Mr. Paul Stokols from the NWS for providing additional information on the wind chill and extreme cold warnings.

# APPENDIX

## Survey Questionnaire

The survey questions in the manuscript are presented below in the same numbering and ordering of the questions from the full survey. Questions 1–6 were completed by the interview teams to capture the date, cluster number, survey number, team member initials, team number, and whether the cluster was in an urban or rural area.

### Prompt

The National Weather Service is responsible for issuing winter weather warnings. These warnings may be heard through various means, such as television, radio, or Internet. First, we would like to ask you some questions about winter weather warnings issued by the National Weather Service.

All answers recorded as either □ Yes □ No □ Don't Know □ Refused

**Q7a.** Have you ever heard an "extreme cold warning" for your area?

**Q7b.** If YES, after hearing the "extreme cold warning," did you take ANY protective action? For example, wearing extra clothing or protecting pets or livestock?

**Q8a.** Have you ever heard a "wind chill warning" for your area?

**Q8b.** If YES, after hearing the "wind chill warning," did you take ANY protective action? For example, wearing extra clothing or protecting pets or livestock?

### Prompt

Now we are going to ask you about extreme cold events. An extreme cold event is an extended period of time of temperatures or wind chill of at least 30 degrees below zero over a large geographical area.

All answers recorded as either □ Yes □ No □ Don't Know □ Refused

**Q9.** Did anyone in your household take any of the following actions immediately before or during an extreme cold event?

- **a.** Wore extra clothing?
- **b.** Stayed indoors?
- **c.** Ensured alternative forms of home heating were available or in working order (in addition to primary heating)?
- **d.** Canceled or adjusted scheduled activities?
- **e.** Changed travel plans?
- **f.** Ensured vehicles were in good working order for the extreme cold?
- **g.** Protected livestock or pets?

**h.** Is there anything else you did to protect your household for an extreme cold event? Specify: _____

**Q10.** What is your household's MAIN source of information for severe winter weather conditions? (read responses, check only one)

- ☐ TV
- ☐ NOAA weather radio
- ☐ Text message
- ☐ Local newspaper
- ☐ Commercial radio station
- ☐ Neighbor/friend/family/word of mouth
- ☐ Internet

☐Other_____

- ☐ None ☐ Don't Know ☐ Refused

**Q11.** If you heard an Extreme Cold Warning, what would you be concerned about? Would you be concerned about…

**a.** Health issues (e.g., frostbite, hypothermia)?

**b.** Threat to animals (pets, livestock)?

**c.** Damage to exposed pipes?

**d.** Automobile not starting?

**e.** Loss of power?

**f.** School/business closings?

**g.** Is there anything else that is particularly concerning to you about an extreme cold event? _____☐ None ☐ Don't Know ☐ Refused

**Q12.** How much warning time would you like before an extreme cold event? (do not read responses)

- ☐ Less than 6 h
- ☐ 6 to <24 h
- ☐ 1 to 2 days
- ☐ 3 or more days
- ☐ Don't Know
- ☐ Refused

**Q13.** How satisfied are you with the National Weather Service's winter warnings and forecasts in terms of its:

All answers recorded either as ☐ Satisfied ☐ Neither satisfied nor dissatisfied ☐ Dissatisfied ☐ Very dissatisfied ☐ Don't Know ☐ Refused

**a.** Accuracy

**b.** Timeliness

**c.** Reliability

**d.** Language used

## REFERENCES


Baumgartner EA. Hypothermia and other cold-related morbidity emergency department visits: United States, 1995-2004. Wilderness Environ. Med. 2008; 19:233–237. Coauthors. [PubMed: 19099327]

Centers for Disease Control and Prevention. Hypothermia-related deaths—United States, 2003-2004. Morbidity Mortal. Wkly. Rep. 2005; 54:173–175.

Centers for Disease Control and Prevention. Hypothermia-related deaths—United States, 1999–2002 and 2005. Morbidity Mortal. Wkly. Rep. 2006; 55:282–284.

Centers for Disease Control and Prevention. Community Assessment for Public Health Emergency Response (CASPER) toolkit. Second edition. CDC; 2012a. p. 91Available online at http://emergency.cdc.gov/disasters/surveillance/pdf/CASPER_toolkit_508%20COMPLIANT.pdf

Centers for Disease Control and Prevention. Extreme cold—A prevention guide to promote your personal health and safety. CDC; 2012b. p. 13Available online at http://emergency.cdc.gov/disasters/winter/pdf/cold_guide.pdf

Hoekstra S, Klockow K, Riley R, Brotzge J, Brooks H, Erickson S. A preliminary look at the social perspective of warn-on-forecast: Preferred tornado warning lead time and the general public's perceptions of weather risks. Wea. Climate Soc. 2011; 3:128–140.

Joslyn S, Nadav-Greenberg L, Nichols RM. Probability of precipitation assessment and enhancement of end-user understanding. Bull. Amer. Meteor. Soc. 2009; 90:185–193.

Kaminsky DA, Bates JHT, Irvin CG. Effects of cool, dry air stimulation on peripheral lung mechanics in asthma. Amer. J. Respir. Crit. Care Med. 2000; 162:179–186. [PubMed: 10903239]

Lindell, MK,.; Perry, RW. Communicating Environmental Risk in Multiethnic Communities. SAGE Publications, Inc.; 2004. p. 272

National Oceanic and Atmospheric Administration. Report on wind chill temperature and extreme heat indices: Evaluation and improvement projects. 2003. p. 75OFCM Rep. FCM-R19-2003Available online at http://www.ofcm.gov/jagti/r19-ti-plan/pdf/entire_r19_ti.pdf

National Oceanic and Atmospheric Administration. cited 2012: Weather-ready nation—Focus on severe weather. Available online at http://www.nws.noaa.gov/com/weatherreadynation/news/022712_focus_severe.html

National Weather Service. Winter storms: The deceptive killers; A preparedness guide. U.S. Department of Commerce NOAA/PA 200160 and American Red Cross ARC 4467; 2008. p. 12Available online at http://www.nws.noaa.gov/om/winter/resources/Winter_Storms2008.pdf

National Weather Service. Windchill terms and definitions. 2009. Available online at http://www.nws.noaa.gov/os/windchill/index.shtml

National Weather Service. Public information statement: Currently soliciting comments by April 15, 2011 on experimental use of an extreme cold warning product. 2011. Available online at http://www.nws.noaa.gov/os/notification/pns11extreme_cold.txt

National Weather Service. Experimental extreme cold warning products—Product description document. NOAA; 2012. p. 4Available online at http://products.weather.gov/PDD/Exp_Extreme_Cold.pdf

Panagiotakos DB. Climatological variations in daily hospital admissions for acute coronary syndromes. Int. J. Cardiol. 2004; 94:229–233. Coauthors. [PubMed: 15093986]

U.S. Census Bureau. State and county quickfacts—Burleigh County, North Dakota. Available online at http://quickfacts.census.gov/qfd/states/38/38015.html

U.S. Department of Homeland Security. 2007: Target capabilities list—A companion to the National Preparedness Guidelines. U.S. Department of Homeland Security; p. 578Available online at http://www.fema.gov/pdf/government/training/tcl.pdf

Zhang FQ. An in-person survey investigating public perceptions of and responses to Hurricane Rita forecasts along the Texas coast. Wea. Forecasting. 2007; 22:1177–1190. Coauthors.

| Warning Name | Time period in use | Criteria for issuing warning |
|---|---|---|
| Wind Chill Warning | 1973 – current | Ambient temperature ≤ -40°F† and wind speed ≥ 3 mph |
| Extreme Cold Warning | Piloted in 2010 – 2012* in ND, SD, AR, MN | Ambient temperature or wind chill ≤ -30°F† |

†The temperature criteria for issuing Wind Chill and Extreme Cold Warnings were set locally. For Extreme Cold Warning, criteria were different for MN (≤ -40°F) and AR (≤ -0°F).

*Extreme Cold Warning was piloted since 2010 for public warning. Prior to this it had only been used in the NWS-Alaska Region to warn the aviation industry against frozen fuels and hydraulic lines.

**Fig. 1.**

Wind chill and extreme cold warnings.

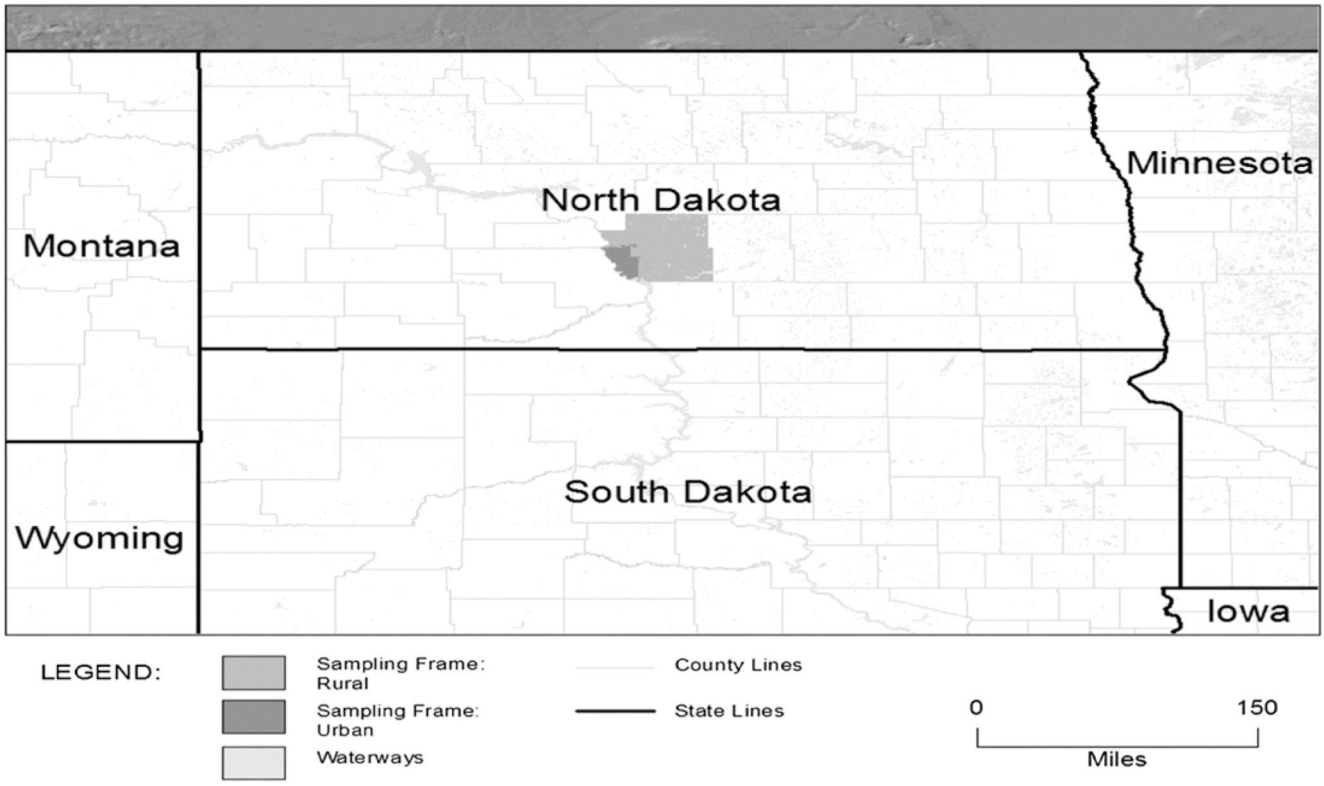


**Fig. 2.**

Geographic location of the sampling frame of Burleigh County, ND, where the CASPER survey was conducted on 10–11 Apr 2012.

## Table 1

Questionnaire response rates in the CASPER survey conducted in Burleigh County, ND, on 10–11 Apr 2012.

| Questionnaire response | Percent ($n$ = 188) | Rate |
|---|---|---|
| Completion[a] | 89.5 | 188/210 |
| Cooperation[b] | 64.0 | 188/294 |
| Contact[c] | 38.9 | 188/483 |

[a] Percent of surveys completed in relation to the goal of 210.

[b] Percent of contacted households that were eligible and willing to participate in the survey.

[c] Percent of systematically selected households that completed an interview.

## Table 2

Winter weather warnings and actions following hearing warnings among residents in Burleigh County, ND, in the CASPER survey conducted on 10–11 Apr 2012.

| | Frequency (*n* = 188) | Households (%) | Projected number of households | Weighted % (95% CI) |
|---|---|---|---|---|
| Extreme cold warning | | | | |
| Heard warning | 163 | 86.7 | 29,763 | 86.6 (80.7–92.5) |
| Took action after hearing warning * | 127 | 77.9 | 23,483 | 78.9 (71.1–86.7) |
| Wind chill warning | | | | |
| Heard warning | 188 | 100.0 | 34,371 | 100.0 (100.0–100.0) |
| Took action after hearing warning * | 159 | 84.6 | 29,105 | 84.7 (78.8–90.6) |

* Of those who heard warning.

## TABLE 3

Concerns after hearing Extreme Cold Warning and actions taken in extreme cold events among residents in Burleigh County, ND, in the CASPER survey conducted on 10–11 Apr 2012.

| | Frequency (*n* = 188) | Households (%) | Projected number of households | Weighted % (95% CI) |
|---|---|---|---|---|
| Concerns after hearing EC warning | | | | |
| No concern‡ | 13 | 6.9 | 2,913 | 8.5 (3.8–13.2) |
| 1–3 concerns‡ | 82 | 43.6 | 14,811 | 43.1 (33.2–53.0) |
| 4–6 concerns‡ | 87 | 46.3 | 15,223 | 44.3 (33.8–54.8) |
| 7 or more concerns‡ | 6 | 3.2 | 1,424 | 4.1 (0.6–7.7) |
| Loss of power | 137 | 72.9 | 24,415 | 71.0 (63.8–78.3) |
| Health issues | 116 | 61.7 | 20,923 | 60.9 (52.7–69.1) |
| Automobile not starting | 114 | 60.6 | 20,886 | 60.8 (49.9–71.6) |
| School/business closing | 95 | 50.5 | 17,360 | 50.5 (39.0–62.0) |
| Threat to pets and livestock | 94 | 50.0 | 15,746 | 45.8 (39.2–52.5) |
| Damage to exposed pipes | 62 | 33.0 | 11,369 | 33.1 (23.2–43.0) |
| Other* | 25 | 13.3 | 4,824 | 14.0 (8.2–19.9) |
| Actions taken in EC event | | | | |
| No action‡ | 1 | 0.5 | 285 | 0.8 (0–2.5) |
| 1–3 actions‡ | 14 | 7.5 | 2,667 | 7.8 (2.7–12.9) |
| 4–6 actions‡ | 102 | 54.3 | 19,048 | 55.4 (46.9–63.9) |
| 7 or more actions‡ | 71 | 37.8 | 12,371 | 36.0 (28.7–43.3) |
| Wore extra clothing | 173 | 92.0 | 31,487 | 91.6 (86.4–96.8) |
| Ensure vehicles in working order | 168 | 89.4 | 30,100 | 87.6 (80.7–94.5) |
| Stay indoors | 163 | 86.7 | 29,713 | 86.4 (79.9–93.0) |
| Cancel/adjust activity | 144 | 76.6 | 26,638 | 77.5 (70.1–84.9) |
| Change travel plans | 134 | 71.3 | 24,568 | 71.5 (64.2–78.7) |
| Protect livestock/pets | 134 | 71.3 | 23,992 | 69.8 (63.5–76.1) |
| Alternative forms of home heating | 105 | 55.9 | 17,619 | 51.3 (42.5–60.0) |
| Other actions† | 51 | 27.1 | 9,791 | 28.5 (20.2–36.8) |

EC = Extreme Cold.

*Other concerns given included road conditions for commuting (*n* = 11), concerns for family (*n* = 3), sufficient supplies (*n* = 3), and others (*n* = 8).

†Other actions given included winterized home (*n* = 28), gathered supplies (e.g., food, water, blanket, batteries) (*n* = 16) and other protective actions (*n* = 7).

‡Concerns and actions as listed in the table.

## TABLE 4

Main source of severe winter weather information and preferred warning time before an extreme cold event among residents in Burleigh County, North Dakota, in the CASPER survey conducted on April 10–11, 2012.

| | Frequency (*n* = 188) | Households (%) | Projected number of households | Weighted % (95% CI) |
|---|---|---|---|---|
| Main information source for severe winter weather | | | | |
| Television | 149 | 79.3 | 27 839 | 81.0 (73.8–88.1) |
| Internet | 11 | 5.9 | 2036 | 5.9 (1.8–10.1) |
| NOAA weather radio | 9 | 4.8 | 1717 | 5.0 (0.6–9.4) |
| Commercial radio station | 15 | 8.0 | 1627 | 4.7 (1.4–8.0) |
| Neighbor/friend/family/word of mouth | 2 | 1.1 | 593 | 1.7 (0.0–4.2) |
| Other * | 2 | 1.1 | 559 | 1.6 (0.0–4.0) |
| Preferred warning time before EC event | | | | |
| Less than 6 h | 15 | 8.0 | 2634 | 7.7 (3.7–11.6) |
| 6 to <24 h | 70 | 37.2 | 13 765 | 40.0 (28.6–51.5) |
| 1–2 days | 85 | 45.2 | 15 433 | 44.9 (34.6–55.2) |
| 3 or more days | 14 | 7.4 | 2062 | 6.0 (1.7–10.3) |

Totals may not add to 100% because of rounding and missing data.

* Other information sources given included looking outside (*n* = 1) and other unspecified reason (*n* = 1).

## TABLE 5

Satisfaction of National Weather Service's winter warnings and forecasts among residents in Burleigh County, North Dakota, in the CASPER survey conducted on 10–11 Apr 2012. Totals may not add to 100% because of rounding.

| | Frequency (*n* = 188) | Households (%) | Projected number of households | Weighted % (95% CI) |
|---|---|---|---|---|
| Accuracy | | | | |
| Very satisfied/satisfied | 156 | 83.0 | 29 200 | 85.0 (79.1–90.8) |
| Neither satisfied nor dissatisfied | 24 | 12.8 | 3987 | 11.6 (5.5–17.7) |
| Dissatisfied | 8 | 4.3 | 1184 | 3.4 (0.8–6.1) |
| Timeliness | | | | |
| Very satisfied/satisfied | 173 | 92.0 | 32065 | 93.3 (89.3–97.3) |
| Neither satisfied nor dissatisfied | 12 | 6.4 | 1802 | 5.2 (1.4–9.1) |
| Dissatisfied | 3 | 1.6 | 504 | 1.5 (0.0–3.4) |
| Reliability | | | | |
| Very satisfied/satisfied | 159 | 84.6 | 29 303 | 85.3 (79.2–91.3) |
| Neither satisfied nor dissatisfied | 22 | 11.7 | 3739 | 10.9 (5.8–16.0) |
| Dissatisfied | 7 | 3.7 | 1329 | 3.9 (0.7–7.0) |
| Language used | | | | |
| Very satisfied/satisfied | 177 | 94.1 | 32 692 | 95.1 (92.1–98.1) |
| Neither satisfied nor dissatisfied | 3 | 1.6 | 448 | 1.3 (0.0–3.0) |
| Dissatisfied | 8 | 4.3 | 1232 | 3.6 (0.8–6.4) |